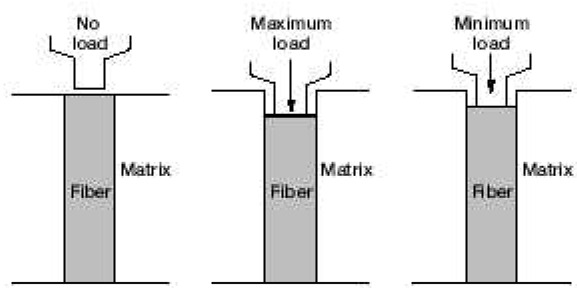
Cyclic Fiber Push-In Test Monitors Evolution of Interfacial Behavior in Ceramic Matrix Composites

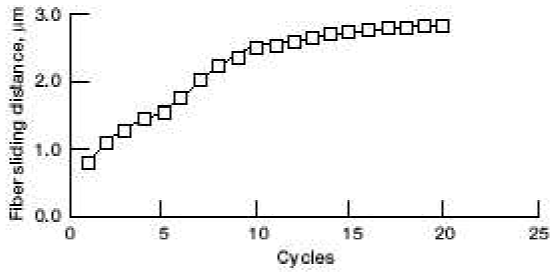
SiC fiber-reinforced ceramic matrix composites are being developed for high-temperature advanced jet engine applications. Obtaining a strong, tough composite material depends critically on optimizing the mechanical coupling between the reinforcing fibers and the surrounding matrix material. This has usually been accomplished by applying a thin C or BN coating onto the surface of the reinforcing fibers. The performance of these fiber coatings, however, may degrade under cyclic loading conditions or exposure to different environments. Degradation of the coating-controlled interfacial behavior will strongly affect the useful service lifetime of the composite material.

Cyclic fiber push-in testing was applied to monitor the evolution of fiber sliding behavior in both C- and BN-coated small-diameter (15-μm) SiC-fiber-reinforced ceramic matrix composites. The cyclic fiber push-in tests were performed using a desktop fiber push-out apparatus. At the beginning of each test, the fiber to be tested was aligned underneath a 10-μm-diameter diamond punch; then, the applied load was cycled between selected maximum and minimum loads. From the measured response, the fiber sliding distance and frictional sliding stresses were determined for each cycle. Tests were performed in both room air and nitrogen.



Cyclic fiber push-in test approach.

Cyclic fiber push-in tests of C-coated, SiC-fiber-reinforced SiC showed progressive increases in fiber sliding distances along with decreases in frictional sliding stresses for continued cycling in room air. This rapid degradation in interfacial response was not observed for cycling in nitrogen, indicating that moisture exposure had a large effect in immediately lowering the frictional sliding stresses of C-coated fibers. These results indicate that matrix cracks bridged by C-coated fibers will not be stable, but will rapidly grow in moisture-containing environments.



Variation in fiber sliding distance with continued cycling for 23-mm-diameter, C-coated SiC fiber in SiC matrix. 20 cycles up to 1.4 N.

In contrast, cyclic fiber push-in tests of both BN-coated, SiC-fiber-reinforced SiC and BN-coated, SiC-fiber-reinforced barium strontium aluminosilicate showed no significant changes in fiber sliding behavior with continued short-term cycling in either room air or nitrogen. Although the composites with BN-coated fibers showed stable short-term cycling behavior in both environments, long-term (several-week) exposure of debonded fibers to room air resulted in dramatically increased fiber sliding distances and decreased frictional sliding stresses. These results indicate that although matrix cracks bridged by BN-coated fibers will show short-term stability, such cracks will show substantial growth with long-term exposure to moisture-containing environments. Newly formulated BN coatings, with higher moisture resistance, will be tested in the near future.

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